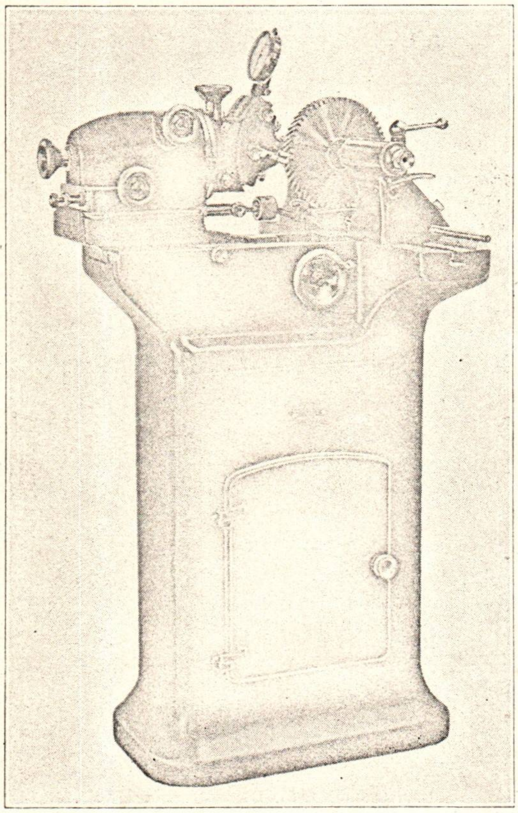
ILLINOIS

Normal Pitch and Space Measuring MACHINE

#337 12" dia x 15"

#437 24" dia x 18"



get data on other machines
& consider offset lower
contact fingers

Manufacturers of Milling Cutters, Hobs, Broaches and Special Tools

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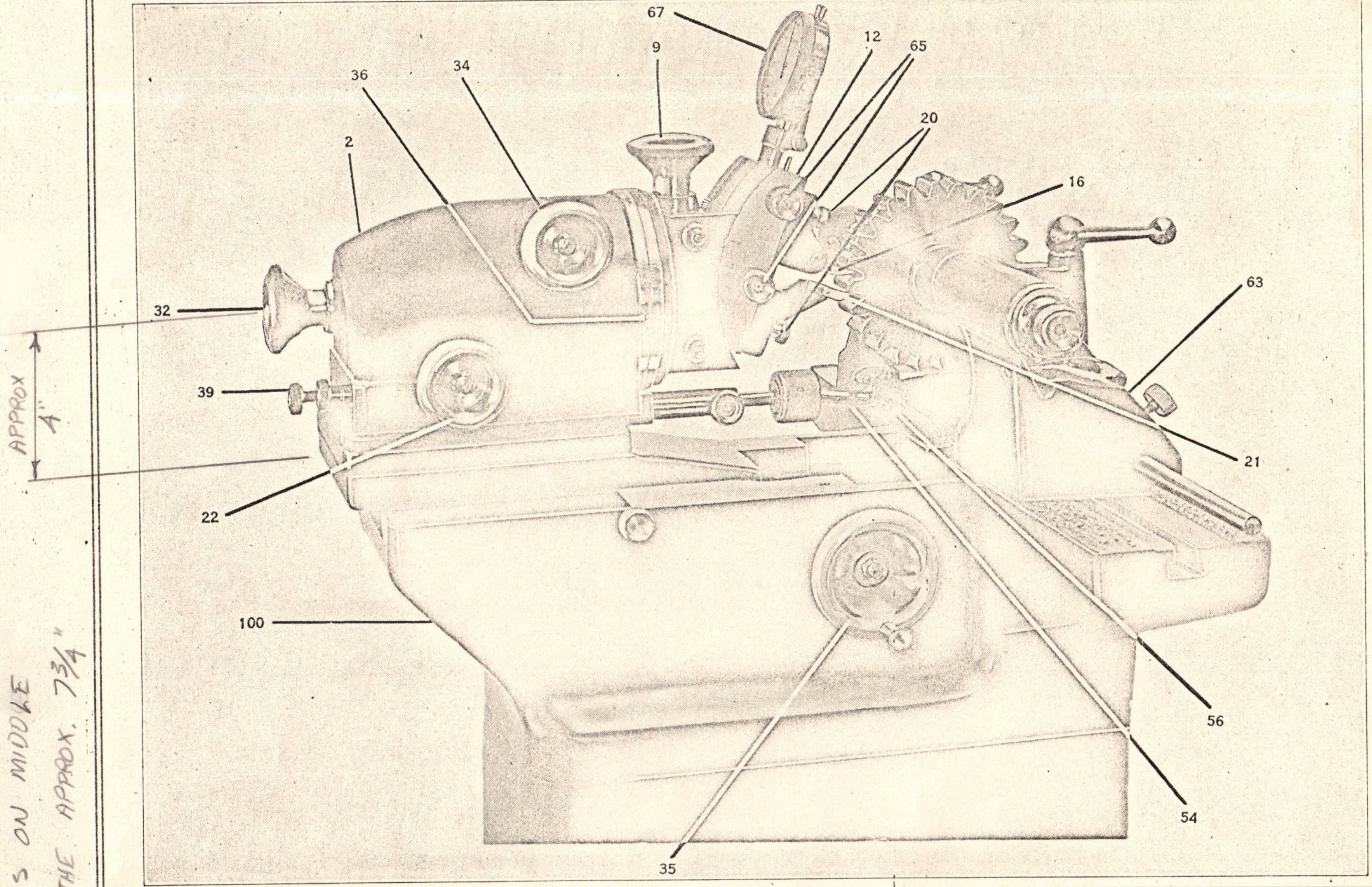

ILLINOIS TOOL WORKS

NORMAL PITCH AND SPACE MEASURING MACHINE

#337—12' DIAMETER 15' BETWEEN CENTERS
#437—24' DIAMETER 18' BETWEEN CENTERS

HT. TOP OF LOWER CROSS SLIDE TO
TO CENTERS ON MIDDLE
ENGINE LATHE APPROX. 7 3/4"

Illinois Normal Pitch and Space Measuring Machine No. 337

THE most vital of all gear elements is *Normal Pitch* and yet, surprising as it may seem, this is one gear element that has received no recognition in the gear shop.

In gear engineering and design, it is of course recognized and employed, but in the production of gears the Normal Pitch is seldom if ever inspected or measured.

This is rather astonishing because of all the numerous instruments and devices brought out for checking practically all other gear elements, Normal Pitch, the most vital one, has been omitted.

It can definitely be stated that:

Normal Pitch is the Index to Gear Performance.
Normal Pitch is the Yardstick of quietness in gears.

The reason for this is plain when it is understood that in the involute system the Normal Pitch is the distance between adjacent gear teeth on the line of pressure upon which the mating action occurs. Therefore, gears that measure alike on the Normal Pitch regardless of their diameters or center distance, will mate quietly.

It is not enough to know that gears are alike in circular pitch (which does not tell the story) but they must be alike in Normal Pitch to mate quietly and efficiently.

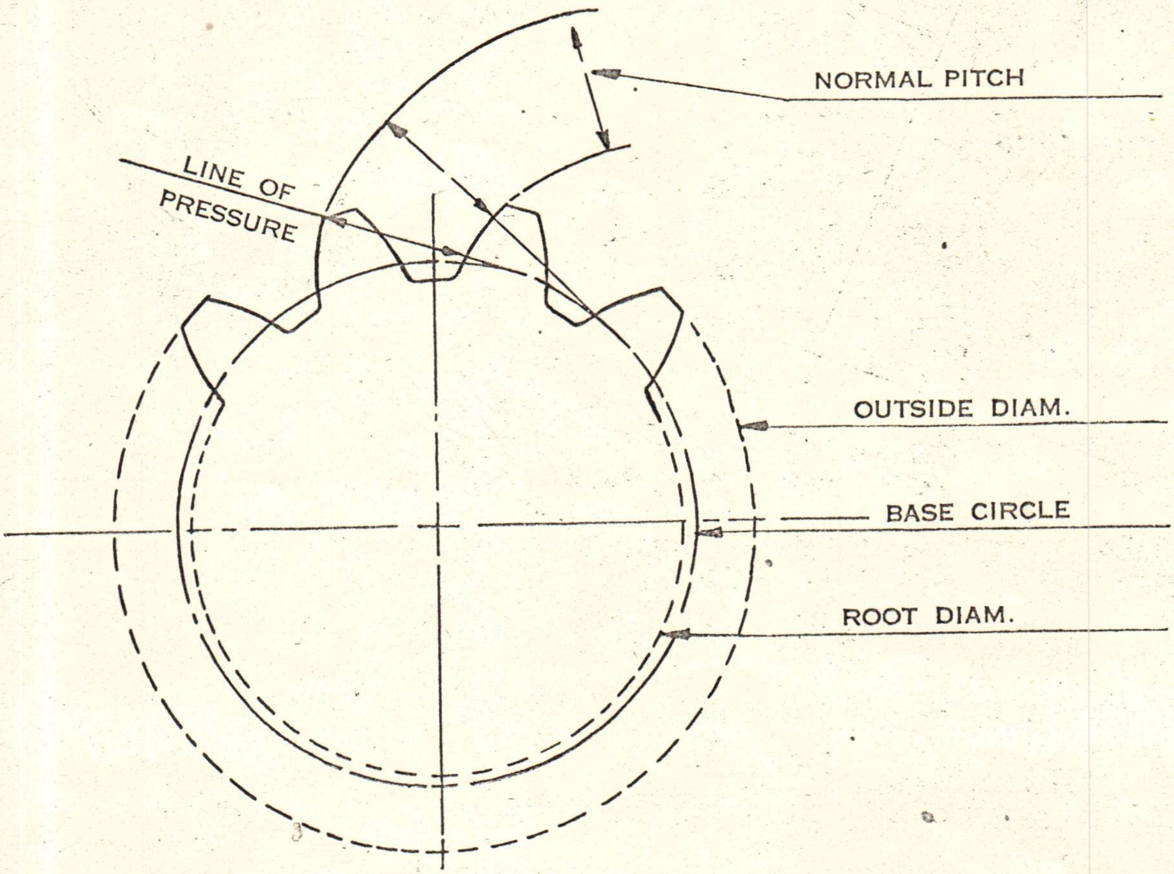

Fig. 1

Normal Pitch = Base Circle times 3.1416 divided by the Number of Teeth

The Illinois Normal Pitch and Space Measuring Machine is designed to rapidly measure Normal Pitch in the rotational plane of gears and to check Spacing in various types of gears in planes other than rotational. The operation is semi-automatic and the average Automobile, Truck, or Tractor gears of 30 teeth may easily be checked on all teeth in one minute.

The machine may be used on its own bed or it may be clamped to any machine that has a pair of centers.

In Fig. 1 is shown a diagram of Normal Pitch.

One of the features of Involute curves is that they run parallel to each other as they extend out from the Base Circle. Therefore, any line tangent to the Base Circle that crosses the Involutes will be the same length between the Involutes at any point of crossing. This distance is called the Normal Pitch.

The other feature that makes this Normal Pitch distance so important is that the mating gear teeth have their contact on this tangent line or Line of Pressure.

Therefore, mating gear teeth that do not have alike Normal Pitches will introduce violent disturbances in the rotating mass.

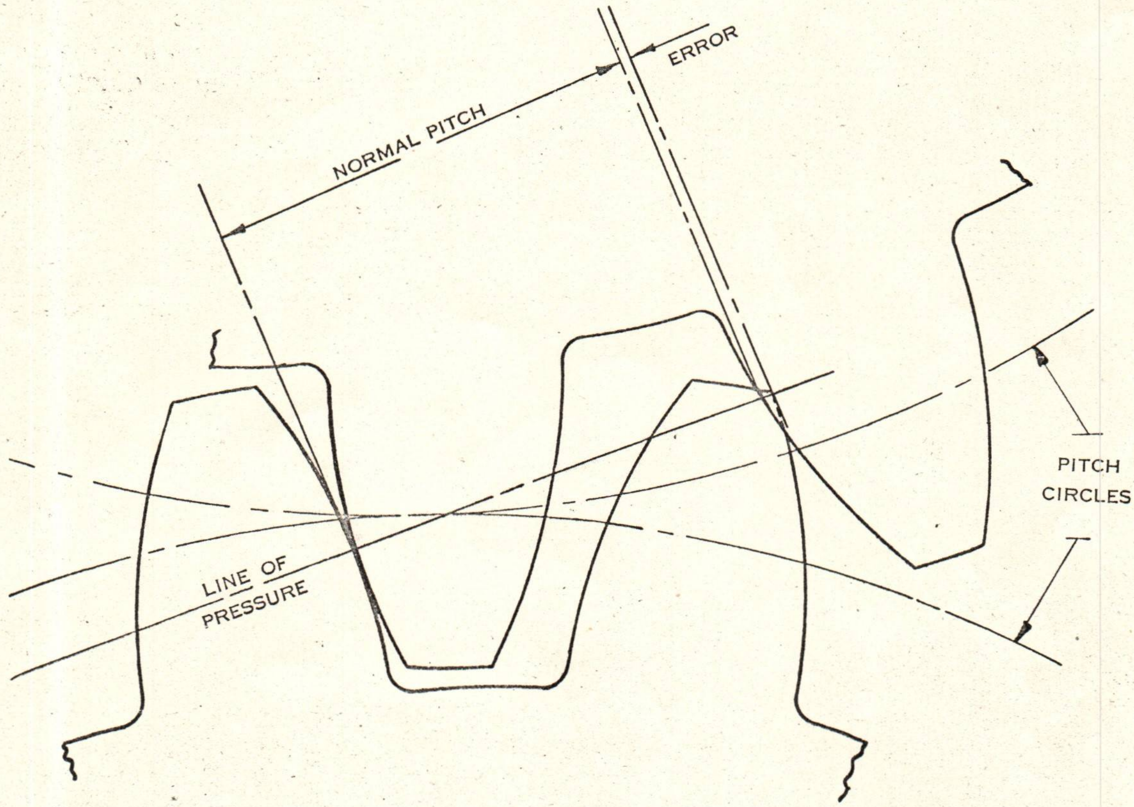

Fig. 2

Fig. 2 indicates the manner in which gear teeth mate. Thus if one 10-pitch 30-tooth, 14½° Pressure Angle Gear had a Normal Pitch of .3041 and the mating gear a Normal Pitch of .3045 there would be considerable clash and noise.

It can also be noted from this diagram that the gear teeth cannot contact simultaneously at the pitch lines or on the Circular Pitch.

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Gears are often checked for Circular Pitch spacing and this may be alike in both mating gears.

In gears that are hobbed, the Circular Pitch is almost always correct because the same hob tooth that cuts at the pitch line on one tooth also cuts on the pitch line on all the teeth in the gear, and the indexing of the hobbing machine is continuous.

In machines using intermittent indexing, or gear cutting tools which do not have the same cutting tooth, repeat in the same spot on successive gear teeth, the Circular Pitch is more apt to be off.

Thus, in purely mathematical gears Normal Pitch and Circular Pitch are complementary to each other. In actual production it is common to get gears with accurate Circular Pitch or tooth spacing and still have an error in Normal Pitch where the gear teeth mate.

Helical Gear

Helical gears have two Normal Pitches.

The Normal Pitch of the Involute curve lies in the rotational plane of the gear or as commonly stated the Transverse Plane.

This Normal Pitch is correctly known as Base Pitch.

The Normal Circular Pitch of the helical teeth lies in the plane that is normal or right angle to the helix angle of the gear. This Normal Circular Pitch is the one that is always used in reference to helical gears, worms, etc.

These two Normal Pitches must not be confused.

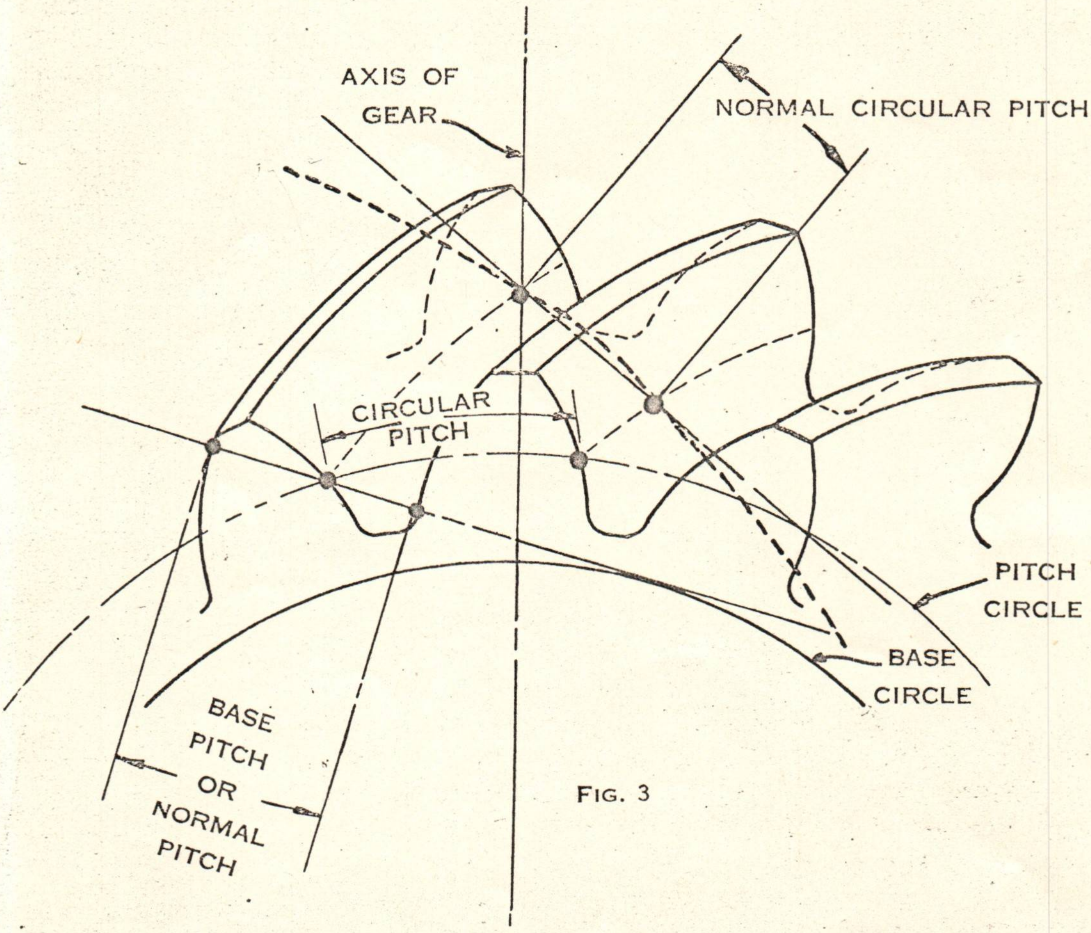

FIG. 3

A study of Fig. 3 will show the three pitches common to helical gears.

Therefore, to check the Normal Pitch of the Involute of a helical gear it is necessary to have the contact fingers of the Measuring machine stand in the rotational or Transverse plane which is perpendicular to the axis of the gear. To find the Pressure Angle at which the head is set it is necessary to transpose from the nominal pressure angle of the gear which is usually given normal to the pitch. Thus,

Tangent of Normal Pressure Angle times Secant of Helix Angle equals Tangent of Transverse Pressure Angle.

In order that the contact fingers may be set tangent to the Base circle so that they contact on the Line of Pressure, a Base Circle is used. To do this the Base Circle is placed between centers and the outer surface of the contact fingers are brought up until they touch or tangent the Base Circle. Then the inward stop of the head is adjusted to keep them in this position. The fingers may then be moved upon their own slide until they are in position to contact two adjacent teeth. Any sliding of the fingers up or down takes place in the tangent line.

To find the Base Circle to use for a Helical Gear:

Cosine of Transverse Pressure Angle times Pitch Diameter equals Base Circle Diameter.

After the Base Circle is obtained the contact fingers may be set up as described in the foregoing.

It is not necessary however to set the head to the Pressure Angle of the Transverse Plane. The head may be set at any Pressure Angle within its scope and the contact fingers would still measure on the Line of Pressure as long as contact fingers are first set tangent to the Base Circle. Fig. 4 indicates how contact fingers may be placed on the tangent line.

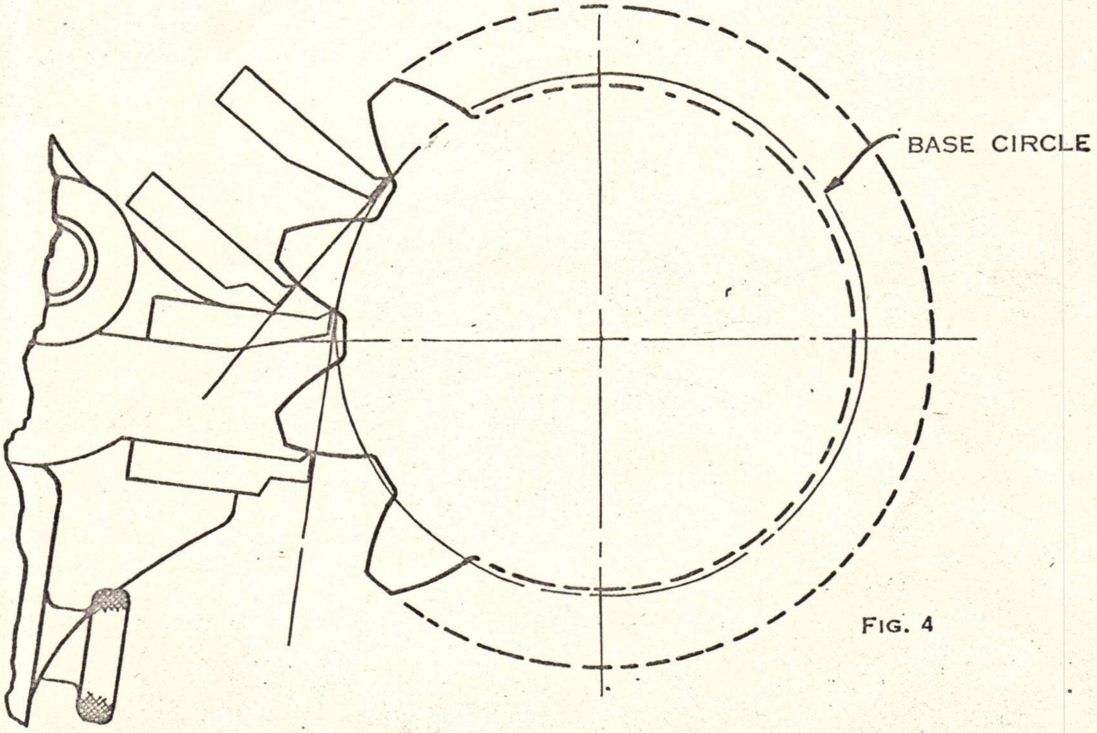

FIG. 4

A Micrometer may be used for measuring the distance between the contact fingers. After the fingers have been set in position and the dial indicator registers zero, the fingers are backed away from the gear teeth and a Micrometer reading is made of the overall distance of the two fingers. Then the lower finger is measured and this amount is subtracted from the overall measurement, thus giving the measurement of the Normal Pitch.

To check the Normal Circular Pitch of the helical teeth on the gear, the head is turned to the helix angle of the gear. The contact fingers are distributed equally on either side of the axis and in this position will check the chordal pitch of the helical teeth. When head is set in this position, the check being made is really a spacing check and compares the spacing of successive teeth.

Worms

The spacing of worm threads, particularly on multiple threaded worms, is often in error and is the source of much trouble when worms run at high speed; even on slow moving worms poor spacing gives an irregular tooth load. Some worm threads are made to have straight profiles in the axial plane, such as would be produced with a lathe tool ground flat on top. Other worms are made to have straight profiles in the plane normal to the thread helix, such as would be produced with a thread milling cutter.

The worm thread when produced with a thread milling cutter does not actually have a straight profile normal to the helix angle, because while the profile of the cutter is straight the cutter operates correctly only on the pitch line helix. The helix angles at the root diameter and outside diameter of the worm are different, and therefore contact the cutter profile in planes normal to themselves. This condition in milling actually produces a very slight convex surface on the thread which is usually acceptable.

Another type of worm thread is made to have straight line elements tangent to its base cylinder. There are several other variations of thread profiles used, but in all cases where multiple threads are employed, the problem of correct spacing is present.

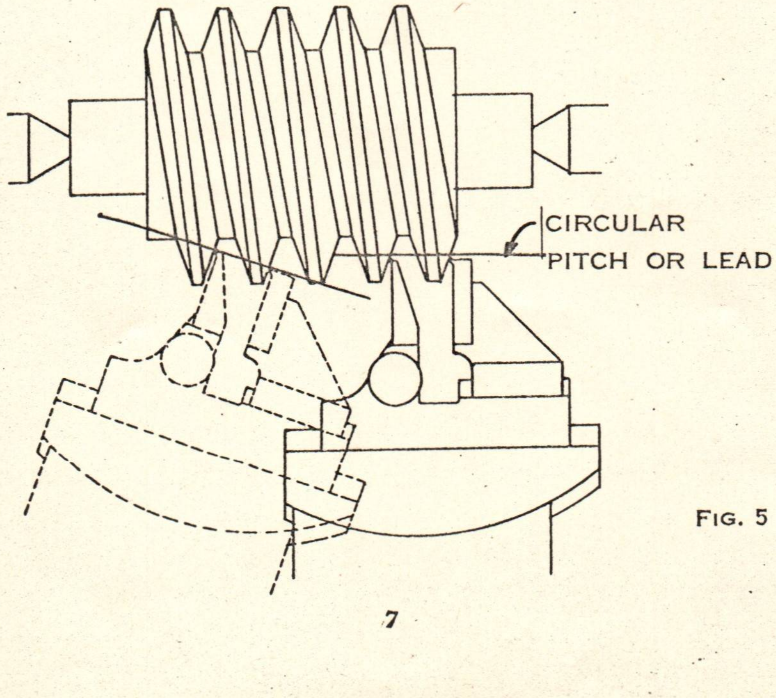

FIG. 5

The Illinois Normal Pitch and Space Measuring Machine is particularly adapted for this sort of checking. Place the worm between the centers and bring the contact fingers into the plane parallel with the axis of the worm. Also have the ends of the fingers parallel to axis. Bring the contact fingers into contact near the pitch line of the worm thread and set the dial indicator to zero. Then rotate the worm to bring another pair of threads into contact. Variations in indicator readings on successive pairs of threads will show the amount of error in axial pitch of the threads. It is in the axial plane that the worm threads contact with the worm gear teeth and therefore, must be correct. Fig. 5 shows the conventional method of checking threads on worms.

Bevel Gears

While it has not been common practice to check Bevel Gears for tooth spacing, there are nevertheless many Bevel Gear jobs which would benefit from an inspection of tooth spacing.

Bevel Gear noise is usually attributed to the improper position of Pitch Cones and to incorrect axis of gears.

However, if both these conditions are correct, it is still obvious that incorrect spacing will cause trouble.

The Illinois Normal Pitch and Space Measuring Machine is especially adaptable for checking Bevel Gears. The Head may be set right angles to any pitch cone angle and the contact fingers adjusted to read either Nominal Normal Pitch or Circular Pitch tooth spacing.

When Nominal Normal Pitch is measured, the contact fingers should be at the large end of the pitch cone as in Fig. 6.

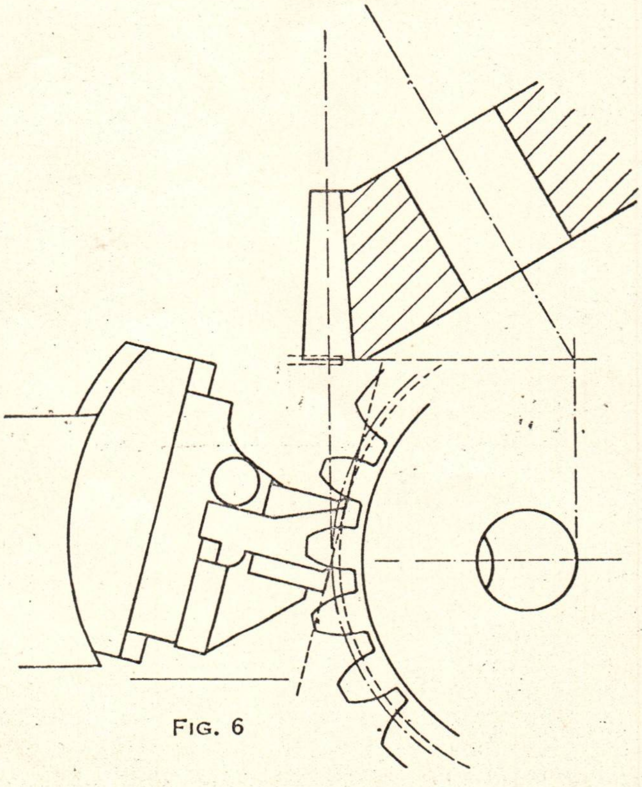

FIG. 6

Checks may be made at the small end of the Pitch Cone or any place in between, but these checks will only register tooth spacing and not Nominal Normal Pitch. This is true for either Straight or Spiral Bevel Gears.

A protractor may be used against the lower flange on the Head, and in this way the setting angle in relation to the gear may be obtained.

The Operation of the Normal Pitch Measuring Machine

Place the proper Base Circle between centers No. 63. Turn hand Wheel No. 9 until head No. 12 sets at the approximate Pressure Angle of gear to be checked. This can be determined by reading the graduated degrees on Head No. 12. Turn hand wheel No. 34 until Head No. 12 is in vertical position as indicated by the zero marks on graduations No. 36.

Release lock screws No. 20 and turn elevating knob No. 65 until lower finger No. 21 is tangent to Base Circle.

This finger has a square end of sufficient width to permit easy visual tangent contact. Then adjust stop screw No. 39 so that finger No. 21 just touches the outside diameter of the Base Circle.

After stop screw No. 39 is once set and locked up with its lock nut, it must not be disturbed during the checking of that particular size of gear. Care must be taken in making this set up to allow the entire head No. 2 to have sufficient stroke back and forth so that contact fingers No. 16 and No. 21 will clear the gear teeth. To assure this, start the set up with stop screw No. 39 in its outermost position. This can be readily done when head is mounted on bed No. 100 by turning hand wheel No. 35 which moves the entire head No. 2 on the bed.

When head No. 2 is used on other equipment, it becomes necessary to adjust by hand to obtain sufficient stroke.

It is of *utmost importance* for checking Normal Pitch that after finger No. 21 has once been placed tangent to the Base Circle, this position is not disturbed by either moving stop screw No. 39, or hand wheel No. 35.

After this setting position is completed, remove the Base Circle from between the centers and insert the gear to be checked.

Move finger No. 21 by revolving elevating knob No. 65 until finger No. 21 just comes inside the gear tooth tip far enough to avoid the gear tooth tip relief. Then lock the finger slide in this position with lock screw No. 20.

Then move finger No. 16 until it touches the next gear tooth enough to give from ¼ to ½ revolution tension on dial indicator No. 67.

After the two contact fingers have been positioned properly against the adjacent gear teeth, bring trip finger No. 56 up against one of the lower gear teeth and lock in position.

The function of trip finger No. 56 is to ratchet the gear around at each stroke of the head so as to bring successive tooth spaces into position for the contact fingers to enter.

Then by turning hand wheel No. 22 until head is against its back stop, the trip finger No. 56 drops into another gear tooth space. As hand wheel No. 22 is turned in opposite direction the head moves forward and trip finger No. 56 rotates the gear until contact finger No. 21 stops the gear. As the head continues to move forward to its inner stop, contact finger No. 16 will register on dial indicator

No. 67. This checking operation is fully automatic and the operator can go around a 30-tooth gear in a minute or less.

When checking *Normal Circular Pitch* on helical gears, or worms, head No. 12 should be set to vertical position or zero Pressure Angle. Then by releasing handwheel No. 32, the contact fingers are swung normal to the helix angle by turning handwheel No. 34 and reading the helix angle or graduation No. 36. After this setting has been made handwheel No. 32 is tightened.

There is very little to go out of order on this machine and its unit construction is such that alignments can be readily made. The contact fingers receive the greatest amount of wear and can be reconditioned on a surface grinder by grinding the ends right angles to the dowel pin holes.

In *Normal Pitch* checking it is necessary to avoid rounded contact points, but in *Circular Pitch* checking the contact points may be purposely rounded.

The machine complete is made in three units. First; the Head which can be used independently on other equipment. Second; the Bed and Center which with the Head makes a bench machine. Third; the Pedestal which with the Head and the Bed makes a complete floor machine. The capacity of the complete machine is 12″ diameter and 15″ between centers. The Head alone is independent of diameters and lengths.

The general dimensions of the machine are:

			Weight	Weight Boxed
Height	52″	Head only	90 lbs.	130 lbs.
Length	27″	Bed and Centers	300 lbs.	430 lbs.
Width	30″	Cabinet Base	300 lbs.	415 lbs.
		Total Weight	690 lbs.	975 lbs.